Using smartphone technology to help improve the interactivity, engagement and the learning experience of students in the traditional lecture environment

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USING SMARTPHONE TECHNOLOGY TO HELP IMPROVE THE INTERACTIVITY, ENGAGEMENT AND THE LEARNING EXPERIENCE OF STUDENTS IN THE TRADITIONAL LECTURE ENVIRONMENT.

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ABSTRACT

More and more educational establishments are looking to integrate new and newer technologies into their learning environments to help support student learning. The eager take up of these systems by management within Higher Education has placed teaching and learning staff in the vanguard of being expected to take up, understand and drive the use of these technologies often without the consequences on student learning having been thoroughly researched.

This paper investigates the effect two technologies, Quick Response Codes and Automatic Response Systems, have on helping improve the engagement of students within the traditional lecture environment and describes our experiences and rationale for moving from the first towards the second.

With smartphone technology becoming almost ever-present in most education settings we developed a conceptual framework, BACDE, (pronounced 'based') that allows a variety of different types of multiple choice questions to be displayed and answered using a smartphone device. All responses can be instantly summarised and displayed in chart form and are then discussed and evaluated jointly by the instructor and class using an in-house web application called Qubed, (Q^3), that caters for Questions, Questionnaires and Quizzes.

This research suggests that this is a highly flexible approach that has allowed us to easily migrate from using QR codes to using the latest interactive version of our web application and appears to be an engaging way of improving formative feedback to students and in helping support and enhance their learning experiences.

Keywords.
Engagement, Smartphones, Quick Response Codes, Automatic Response Systems.

1. INTRODUCTION

Most of the students studying at University these days have grown up with general availability and accessibility to computer technology, communications networks and the Internet. Prensky [1] termed our students as digital natives who have enormous access to these digital technologies. Education must continually evolve or risk feelings of obsolescence as students have access to always on information. This has led educators to come up with alternative techniques and tools that have to be evaluated and judged for appropriateness in educational environments such as higher education. Our task, as educators, is to educate these students but what form will the learning take and what do we need to know now to address this? How should educators balance the demands of students with the demands of education? How should we balance demand for innovation while capitalising on existing best practices and pedagogical theory?

Mobile telephone and smartphone uptake in particular has increased dramatically over the last few years. IDC [2] predicts the worldwide smart connected device market, comprised of PCs, tablets, and smartphones, is forecast to grow 27.8% year over year in 2013. See Figure 1.

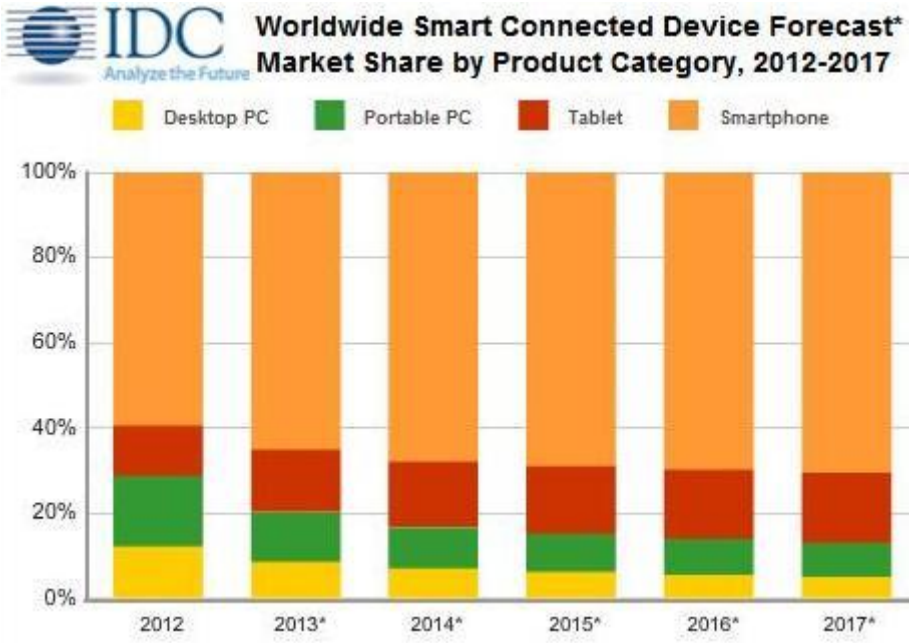


Figure 1: IDC Worldwide Smart Device Forecast.

With this apparent increase in mobile technology being evidenced in the general population it doesn't seem farfetched to expect our students to have access to one or more of these devices. And, furthermore to expect them to assume that they can use such devices as educational tools in pursuit of their learning.

Already this is being evidenced in many institutions as IT departments develop a strategy to cater for "Bring Your Own Device" (BYOD) so they can plan and manage the introduction of such devices to the internal infrastructure of the company. BYOD refers to the practise of students using their own computing devices within the classroom, Handal et al [3]. These devices have traditionally included laptops, but increasingly feature smartphones and tablets, which overcome the size and weight issues of older desktops and laptops, and offer a high degree of mobility and flexibility whilst lessening the constant need for IT departments to upgrade IT infrastructures, Evans & Matthew [4]. Connectivity has also experienced a similar transition from no connectivity to globally interconnected networks and now to the potential of full wireless communication. The capabilities of smartphones have much improved to the point that such devices can be deployed within an educational setting to provide a variety of different learning experiences for our students e.g. enhanced communication options between staff and students, access to video and audio technologies for mobile blogging, the ability to store thousands of books and articles, as well access to the ubiquitous web. A check on Apple App Store, Google Play, and Microsoft's Windows confirms the proliferation of apps for the major mobile marketplace.

Although some mobile devices and smartphones can be cheaper and more portable than personal computers there are still technical limitations which prevent mobile devices from gaining complete acceptance as the device of choice for students as an e-Learning device. Screen size can severely limit the amount of data that can be displayed easily to viewers while processor limitations have implications for the types and quality of data that can be visualised. Of course, these negatives have to be weighed against the benefits of portability and immediacy of learning so students can access data as and when required. This means that mobile devices can become a highly personalised communication medium that can be used to run a wide variety of applications. Stead et al. [5] concluded "learning worked best for learners and tutors when it went beyond the mobile device, and incorporated other media or experiences" whilst Cochrane and Bateman [6] suggest that mobile learning is a rapidly developing paradigm driven by exponential changes in the capabilities of mobile technologies and their integration with Web 2.0 social software.

The mobility enabled by wireless communication, combined with an expanding class of wireless-equipped portable computers and smartphones is challenging staff to consider additional ways in which institutional virtual learning environments (VLE's) can be used to keep students informed 24X7. Consequently, the notion

of where a student learns is having to change because learning can now occur both in and out of the lecture room. It can occur in both formal and informal settings, and can be done by one student on their own or with others in a group.

2. LITERATURE REVIEW

Alexander Astin [7] proposed his developmental theory of college student involvement which he later renamed "engagement". His theory was based on five tenets and he defined engagement as "the amount of physical and psychological energy that the student devotes to the academic experience". Kuh [8] conceptualised engagement as the time and effort students invest in educational activities that are empirically linked to desired college outcomes and emphasises two major aspects which cover in-class and out-of-class engagement and suggest that both are important to student success. Pascarella and Terenzini [9] highlight the relationship between student engagement, student development and success where they emphasize engagement in class discussions and involvement with staff. They suggest that students' perception of staff as being accessible, caring, and helpful promotes persistence and hence degree completion.

Bandura [10] discussed the impact of social learning while Vygotsky [11] described his ideas of collaborative learning in terms of social interaction that involved a community of learners and instructors. Lave and Wenger [12] articulate a view of situated learning as, "an integral and inseparable aspect of social practice" which is captured in their descriptions of "Legitimate Peripheral Participation". All of these notions of working together seem extremely relevant to today's learner, characterised as the NET generation. Our tech savvy students are characterized as preferring teamwork, experiential activities, and the use of technology. Oblinger [13] discusses 'Millennials' and Prensky [1] calls them "digital natives" referring to the fact that they have grown up with technology as opposed to "digital immigrants" who did not. The social nature of Net Geners as well as their desire for experiential learning, implies that interaction is an important technique for colleges and universities to employ. If experiential learning is important for today's learners then we, as educators, have to be aware that the use of lectures may not be the best learning environment for our students. According to Cotner et al [14] traditional learning methods can hinder interactions in the classroom. Draper and Brown [15] identified that limited class time, rigid seating arrangements and students' reservations about speaking out in class were seen as barriers to high levels of interactivity.

This review is concerned with two such technology products that have been considered over the years as being capable of helping to increase the amount of interactivity of students viz Quick Response Codes and Automatic Response Systems in the form of quiz questions that can be used to gather data on students understanding and opinion.

QR (Quick Response) Codes are 2D barcodes which can be read by free software available on most mobile devices but can be downloaded from many sites; e.g. Google Play Store and Apple App Store; if not loaded by default on the mobile device and so is widely available for most types of devices and is usually free. QR codes were developed in 1994 by Denso Wave [16] and have been expanded to include text, URL's etc. where a growing trend for QR codes usage is to be found on web sites, blogs and social networking sites. Interactivity is defined in the QR code context as the ability to supply information with minimal lag time to provide available problems solving mechanisms. The use of QR codes in Education, Ramsden [17], can be used to provide points of information and to aid assessment, Susono et al [18]. Shin et al [19] suggests that QR code activity is perceived to be a social activity comprising entertainment, education and socialization. Canadi et al [20] predict that QR codes are likely to evolve as an interaction channel that enables users to connect with online communities through social networking services.

The application of mobile technology to such a wide range of potential learning scenarios suggests that there is further potential for such devices in other areas of learning and is attracting a growing body of research e.g. Roschelle [21], Sharples et al [22], Cochrane et al [23]. Yu, [24], observed three major ways in which smartphones were being used in higher education:

1. Using in-built web browsers to access materials online
2. Using applications to access and interact with course content
3. Using Quick Response (QR) codes, scanners and augmented reality (although QR codes and augmented reality have failed to make an impact in higher education)

Early adoption of QR code usage has been fragmented and not well researched. However, there seems to be the opportunity for widespread consideration by education establishments, Law & So [25], as the number of students owning a mobile device has grown rapidly with latest survey suggesting that eight out of ten students own a smartphone, UCAS Media [26].

Automatic Response Systems allow an entire class to respond to multiple choice questions and is one approach that helps to make classroom learning more active. These types of systems are known in the literature by a wide range of alternative names including “Personal response systems”, “Electronic voting systems”, “Interactive voting systems”, “Classroom assessment systems” and “Clickers”. In many education establishments the use of clickers has become an integral part of the student learning experience, Homme, Asay & Morgenstern [27].

As more educational institutions integrate clicker technologies into their learning environments staff have to understand how the use of such technologies affects the learning of students who are asked to use such technologies and be aware of the limitations and possible novelty effects that may be inherent because of first time use, Clerk [28]. Clicker Assessment and Feedback (CAF) is an instructional assessment and feedback strategy that is incorporated with interactive technologies and can be an easily adopted teaching approach for higher education, Bruff [29], Stes et al [30]. Weimer & Lenze [31] suggest that CAF development showed a medium effect on both student engagement and learning and a large effect on student engagement. Student perceptions vary depending on whether CAF is being used for Formative Feedback (FF) or Summative Feedback (SF). Students tended to rate their levels of engagement and learning much higher when CAF was being used for formative feedback rather than summative feedback. James [32] and James et al [33] findings showed that professors formative use of CAF has more impact than professors use of summative feedback on student perceptions and engagement. And yet, according to Fies and Marshall [34], Kaleta and Joosten [35] there is a lack of quantitative studies that help us to better understand the role of clickers in student learning.

Numerous publications have highlighted how formative assessment methods can significantly improve student learning (Black & Wiliam [36]; Keeley [37]). Knight & Yorke [38] studies suggest that formative feedback strategies out perform the counterpart on various student experiences or outcomes and so it could be argued that formative assessment and feedback strategies might have more effect that summative counterparts on students in different settings.

Murphy and Sharma [39] suggest that the research literature available for the topic of interactive lectures and the related pedagogical issues are “almost non-existent, with major issues waiting to be examined… inadequate research on the pedagogical implications of the emerging interactive forms of learning.” With this in mind there appears to be an opportunity to examine and suggest how ARS technology could be used to not only enhance lecturer-student interactions but develop the underlying pedagogical issues inherent with lectures.

3. SYSTEM INTRODUCTION – WHAT WE DID. XXX

In 2012 one of the authors gave a presentation to the Education Research group about work that he had been preparing for a paper that was imminent, Law [40]. This work entailed a pilot run of an in-house system using Google Doc and QR Codes that the author had built to investigate how to overcome one of the suggested shortcomings of the traditional lecture viz. the lack of interactive opportunities. At around the same time the second author was working on similar ideas to help break up the lecture slot into more manageable chunks using techniques from Angelo & Cross [41] such as minute papers. This work centred round the use of ‘Quick Quizzes (Q^2)’ that asked students Multiple Choice Questions within the lecture and spent time discussing the answers to those questions. It was obvious that these two ideas had similarities and so a joint Caledonian Scholarship proposal was submitted to work on a project looking at improving student engagement and interactivity in the lecture environment.

The review of the literature has indicated that the use of computer technology has benefited the student learning experience and that much emphasis is now moving towards the use of newer technologies. Our first attempts in this area involved the use of smartphones and QR codes. Following the findings of that trial run

we have further enhanced the system to produce a bespoke application that deals with some of the issues raised during out first attempts.

The use of apps (application or program) on smartphones has increased dramatically in recent years [42] and covers many different domains from entertainment to everyday usage including email, podcasting and reading books. This paper explores the use of a purpose built mobile web application that asks students to use their phones/mobile devices/tablets to support their learning. The application uses Multiple Choice Questions (MCQ's) which has long been used in education as a device to supplement student learning e.g. Denny et al [43].

Here we briefly document two attempts by the authors to bring the use of smartphone technologies to modules in the School of Engineering and Built Environment (SEBE) at Glasgow Caledonian University. The focus of this pilot was to explore the ideas of helping to motivate and improve engagement within the lecture environment.

3.1 QR-CODES

In this section the discussion will focus on the initial pilot tests undertaken using Google Sheets and Google forms. These initial pilot sessions were designed to gauge the viability of interactive lectures within the authors' institution.

The initial trials were undertaken with two cohorts; at year 2 and year 4 (final year). Both cohorts were from the BSc Games Software Development degree. Together both cohorts equated to around 50 students. It was decided to approach each cohort in a different way; giving different feedback to the process. The first approach was based on consecutive lectures which would ramp up the number of questions the students would be asked. The first Lecture had one question only; the question was undertaken at the end of the lecture. The second Lecture had three questions; each positioned at the end of the relevant sub topic. The first two lectures, the questions only had two options. The third Lecture had four questions; again positioned at the end of the relevant subtopics, each with three options.

The second approach was based on non-consecutive Lectures. Both Lectures had two questions with three options positioned at the end of the relevant sub topics. The first approach was undertaken with the year 2 students and the second approach was undertaken with the year 4 students.

Each question was accompanied by the relevant number of Quick Response (QR) codes required for the number of options available for the question. The QR Code contained a URL to a Google sheet. This URL contained the location details for the Google sheet and text relating to one of the answers.

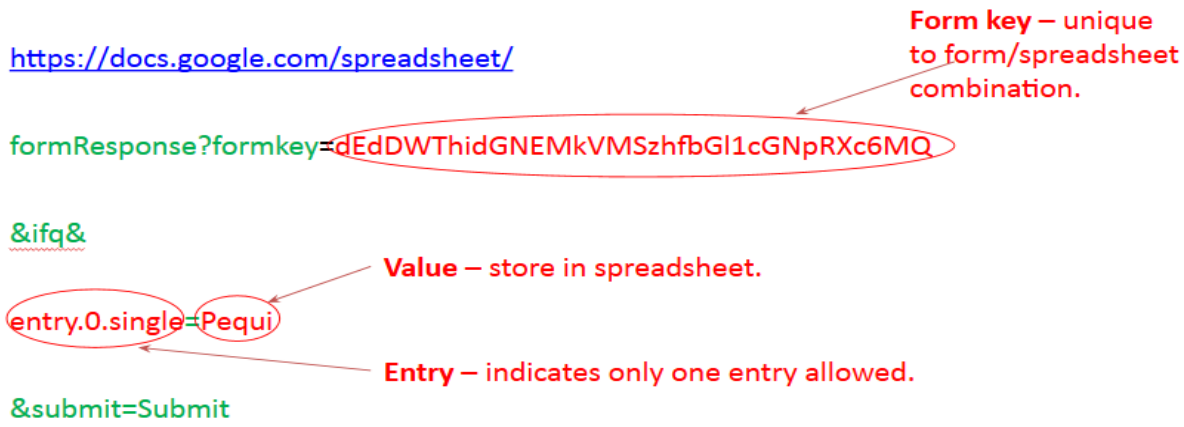


Figure 2 - Spreadsheet URL

Scanning the QR Code invoked the mobile phones browser enabling the student to submit an answer. The answers were processed in near real time by the scripts attached to the Google sheet. This allowed a chart of responses to be generated for the students to view.

Figure 3 - Google Script

At the appropriate point within the lecture the students were issued with a paper based copy of the slide being displayed. This allowed the students to scan the QR Codes more easily.

The QR Code system proved a good testing ground for the interactive lecture concept allowing for quick prototyping and quick deployment for testing the pedagogical theories. However, it was decided that a more durable, robust and expandable system would be needed. As such the Qubed system was developed as a natural progression.

3.2 QUBED (QUERIES UTILISING BROAD EVALUATION AND DISCUSSION (Q^3))

The application has been written using PHP (PHP: Hypertext Preprocessor) web scripting language while the backend database system is implemented using MySQL. The application makes heavy use of the javascript jQuery Mobile framework but is not restricted to any specific client mobile device. In fact, one of our design aims was to build an application that would be able to run on any device, including desktop, laptop, tablet and smartphone without any modification to the code base.

Our prototype called qubed, Q^3, uses our learning framework called BACDE, see fig 4. The framework allows teachers to BUILD a question bank of Multiple Choice Questions (MCQ's). From the associated question bank staff can ASK a query which can be released to students at appropriate times within the traditional lecture period. Students take time out of the lecture or class to CONSIDER the question and then, using their smartphone or mobile device, provide an answer to the question. Once students have been given sufficient time to answer the question the member of staff can interrogate the database to find out how the students have responded to the question. A graph of the student responses is immediately produced and staff and students DISCUSS the question and answers. Our final suggestion is that all staff should EVALUATE the learning situation that has just taken place.

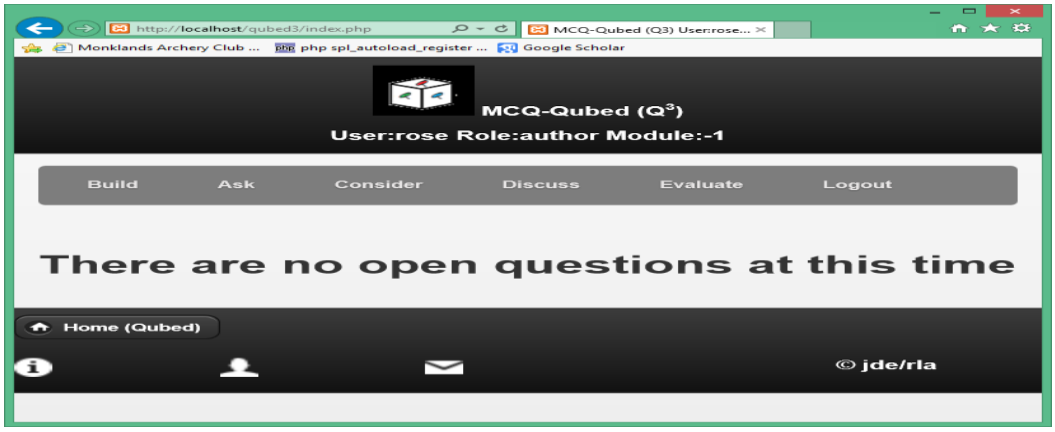


Figure 4: Screenshot showing logged on author.

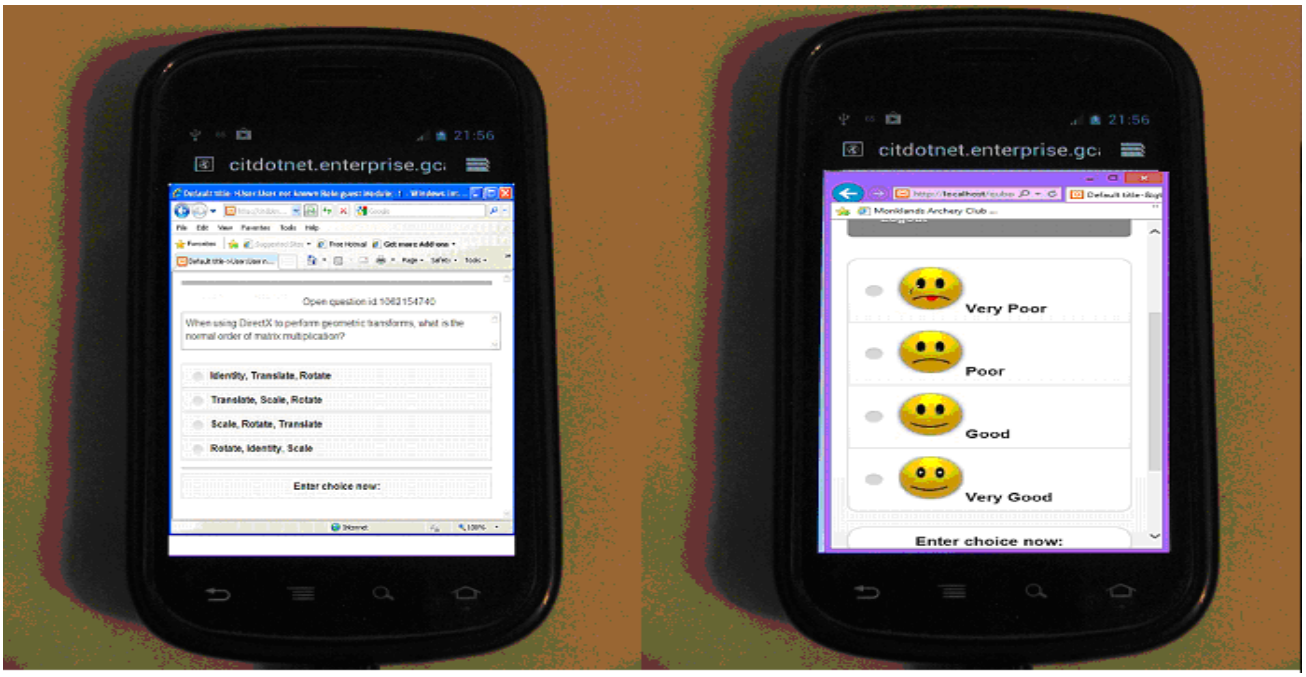
The prototype exists in two specific forms depending on the type of user: 1) the student's view and 2) the author or administrator's view. These two separate applications look after the different views although they each access the same common backend database.

3.2.1 STUDENT'S VIEW.

Non authenticated users of the qubed application are limited to being able to answer and rate the query types which can be of type: 1) question, 2) questionnaire or 3) quiz.

Once a question has been built a randomly produced query identifier is provided by the system and through this identifier specific questions can be answered. Example usage might be as follows:
http://citdotnet.enteprise.gcal.ac.uk/miscellaneous/qubed3/qubed.php?id=010180001

Students who type this or an equivalent URL into the web browser of their mobile device will see the question and the set of possible answers. Students choose an answer and all responses are saved into the backend database so that they can be accessed by the instructor to provide feedback to the users at some time later in the lecture. Once the question has been answered the user has an opportunity to give the instructor feedback on the effectiveness of the question by rating the current question. NB This is optional for users.



Question and 4 options. **Rating screenshot and 4 options.**

Figures 5a & 5b.

3.2.2 AUTHOR'S VIEW.

Authors and administrators can ***Build*** a question which can be given to students. The author gives a title to the question and chooses the type of question. Currently the system allows for a mix of different types of question, see Figure 6 opposite, including:

True / False
Yes / No
Multiple Choice
Likert 5
Likert 7
Multiple response
Lecture specific content.

The outcome of building a question is that the system produces a random identifier which is used to retrieve the question details.

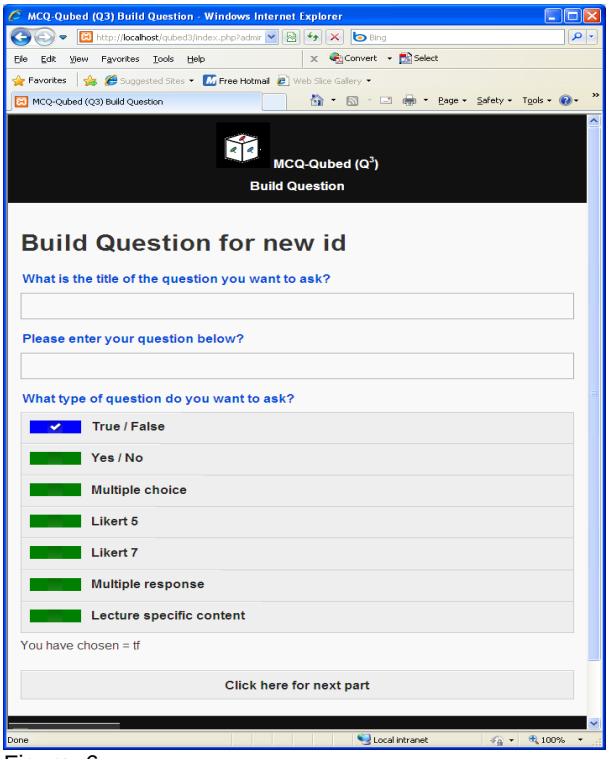


Figure: 6

ASKing a question is a simple process that releases a particular question for answering. This means that users of the system can now take the question and provide answers. Users of the system ***CONSIDER*** the question and the possible options and provide an answer. All data (answers) are saved onto a backend database that can be accessed by the instructor to provide feedback to the users immediately. Staff and students can ***DISCUSS*** the question and answers at this point. This feedback is provided in the form of a graph that indicates the number of replies for each of the given answer options.

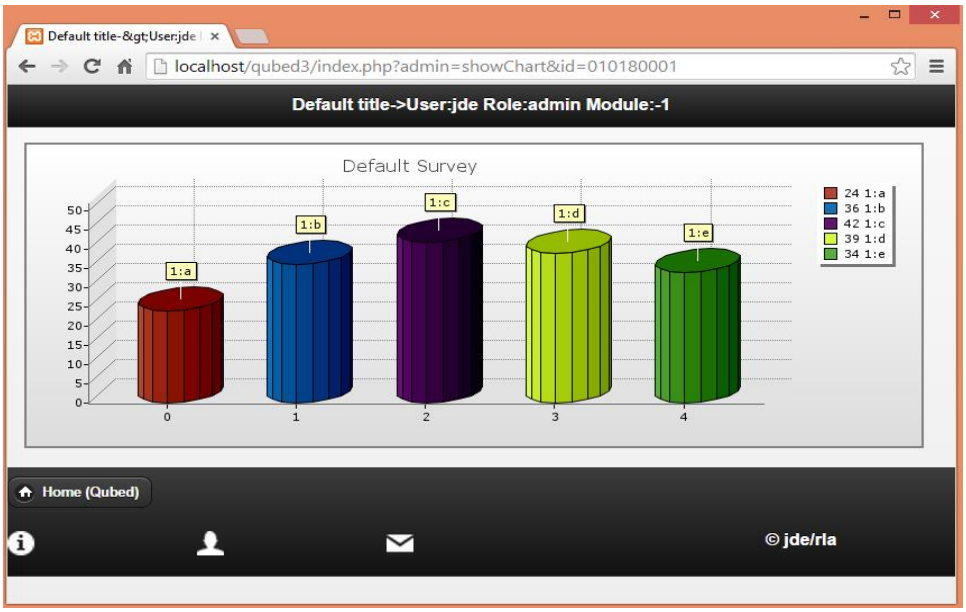


Figure 7 : Screenshot showing counts of responses to particular question using vertical bar.

Graph styles can be hbar (horizontal bar), vbar (vertical bar) or pie and each of these can also be represented as a percentage which in many situations can be more advantageous.

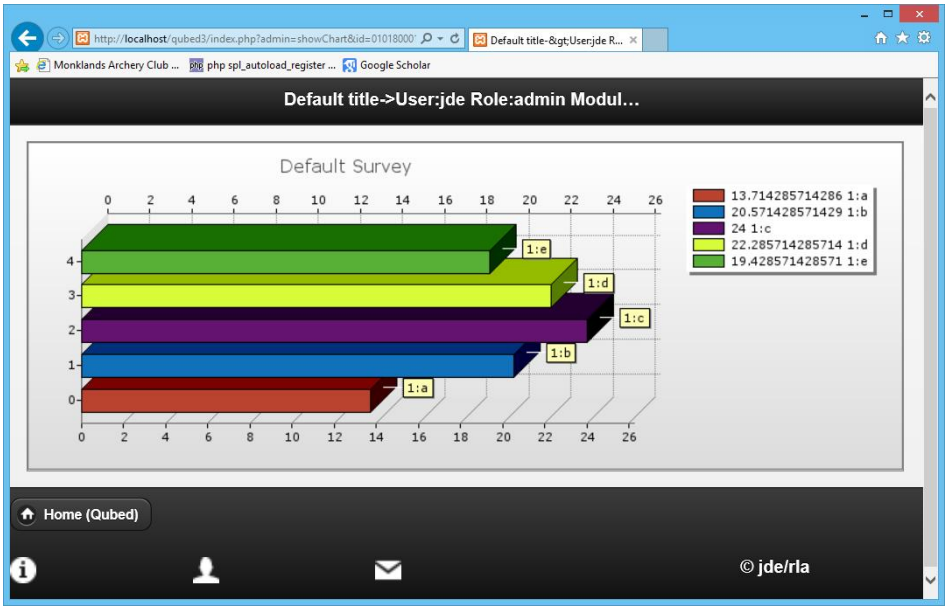


Figure 8: Same question as above but using horizontal bar with percentage figures.

This in-class feedback has a benefit for both student and staff members. Students can see at a glance whether they have got the answer correct and also how well they have performed in relation to the rest of the class. This formative feedback can help students to assess how well they are understanding a particular topic and similarly staff can see how well students have understood the current topic being discussed e.g. too many incorrect answers might imply that the topic has not been successfully delivered and understood by the students. Staff in this situation could revisit the topic and cover the material in a different way or just reinforce the material by going over the material a second time.

It is envisaged that the feedback and discussion opportunities that the immediate displaying of the results brings will create new learning opportunities for students. This is a key factor in our approach which hopes to help students improve their skills in understanding what feedback is and how applicable it is to enhancing their understanding of a topic.

Usage of the system brings into play different factors for both staff and students. Students have their own extrinsic and intrinsic motivational factors about how, when and if they are willing to get involved with using any new technology. Often there can be a wide mismatch between the two as some students are clearly only ever interested in passing the module or a specific assignment.

4. Discussion and Future Work

It appears that the use of interactive lectures dovetails nicely with aspects of our 'BACDE' framework as the use of mobile technology enables, engages and empowers both the student body and the lecturer. It would be fair to say that the principle of interactive lectures has been well received by students; however, feedback from students has indicated that there are a few issues that need to be resolved. One such issue is the delivery mechanism to allow the students to submit an answer electronically. Different approaches have been considered and tested including typing in the complete URL, partially typing the URL and saving it as a bookmark and the use of QR Codes. Reaction from the students suggests that their preferred means of interaction is scanning the QR Code. They note the simplicity in the idea of point and click. However, the students have proved that the current quality of cameras on smartphones is such that paper based copies of the QR Codes is still required to supplement the slides. The quality of cameras is improving as can be seen with the latest iPhone and Samsung releases which offers hope for the future.

The authors also note that there are potential drawbacks to the introduction of such a technology that not all students have access to such a device, visually impaired students might have problems using QR codes while students with mobility issues may have access problems. Students who have behavioural problems e.g.

autism or students with reading issues such as dyslexia can all become excluded from any such pilot studies. Potential solutions include the writing of practical guides to outline the use of QR codes, the placement of QR codes and the discussion of concerns for those students without access to mobile phones.

Although we have tried to make the follow on system as easy to use as possible there have been occasions when the number of responses from the students has been poor. In speaking with the students a number of reasons came to light as to why the participation wasn't as good as we would hope including i) typing in the URL was too much 'hassle', ii) I don't have a smartphone or I left my phone at home, iii) the system didn't work when I answered the question and iv) I answered the last question.

The number of questions asked within a lecture and the point within the lecture that the questions are asked is crucial. Students indicate that too many questions within the lecture and they lose interest. This was the case with the third lecture given to the year 2 cohort which had four questions in it. Anecdotal evidence from the students points towards two questions being the optimal, although this will require further and more rigorous investigation. Students mainly appreciated the point at which the questions were asked, understanding that the questions were acting as a topic review mechanism that would help them find out how well they understood a topic. It seems that for optimal use of the interactive lecture a balance must be struck between the number of questions used in the lecture, the number of options for each question and the placement of the questions within the lecture. Too much of any of these and the students will begin to become immune to the technique. It is also important to note that both the lecturer and the students feel that they are getting some form of benefit from the use of this technique hence the need to find the correct balance of usage.

One of the successes of the system was the immediacy of the feedback that students received and commented on. They said that the length of time between a question being given out and the feedback for the question can be too long.

An area for further investigation is to use the interactive technique in a tutorial setting. Using the interactive technique a thought provoking question would be posed that will invigorate the students encouraging them to engage in discussion. The question would be posed to the student body; the response chart generated and shown with the intent to stimulate discussion based on the responses shown in the chart. Similarly, it was pointed out that the use of Multiple Choice Questioning would not be suitable to all types of programmes that we teach across the University.

5. CONCLUSIONS

Smartphones and mobile devices can compromise security and privacy, some have deficiencies in processor and screen resolutions, and can be a source of distraction and yet it is clear that personal devices including smartphones form an integral part of our connected lives. We should always ensure that using technology for some practical purpose, and not for the sake of using technology, must be the clear objective. "Students are often the guinea pigs in 'IT-enabled' classes as staff test out whether the latest innovations actually help learning". Staff, therefore, have to ensure that the use of the technology is to facilitate learning in the classroom.

So does the introduction of new technology into our classrooms mean that we have to alter our views of how we teach and how students learn? The answer to this question isn't clear cut as there has always been a close relationship between pedagogy and technology innovation as staff explore new ways of doing old or similar things in newer or fresher ways. Our students may be the NET generation who have had access to all sorts of new technology from an early age but we have to be careful and not assume that because they are adept at using the software and hardware it doesn't necessarily follow that they are learning.

The authors have noted student comments that they liked being able to use the system anonymously as it allowed responses from them to be gathered in a non-threatening way. This certainly helps to overcome the issue of only getting answers from dominant individuals which quite often the case especially when questions are asked in a lecture/classroom setting.

There was concern amongst staff as to whether students can achieve much from using online learning environments generally, and particularly with mobile devices given their compact nature. However, our brief use of the system thus far, seems to indicate that the use of Multiple Choice Questions in the lecture

environment is likely to have a positive impact on the learning of our students and that they themselves appeared to be satisfied with the experience.

Following on from the hardware issues that we encountered with the use of the QR Codes system we decided that one of our primary goals would be that the new system would be easy to use and secondly that it should be able to run on a wide variety of mobile devices. The fact that we have designed the system to run in a web browser goes a long way towards helping us achieve both of these goals. This means that most students who have a mobile device should be able to use the system in a variety of environments so long as they have internet access.

It seems to the authors that the use of formative MCQ's during a module can motivate students to learn basic concepts and theories earlier than they would normally do, especially, if they usually only prepare for the final summative examination. The makeup of the MCQ's is crucial to the success of this type of system as often the questions can be used to 'test' only facts and figures. Care should be taken to ensure that the questions cover a mixture of learning outcomes. The early feedback from the pilot usage by staff and students has been encouraging but has not thoroughly explored or tested some of these ideas. By focusing on the collection of certain types of data it is our intention to investigate the student experience in more detail as we consider the implications for the usage of our system.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

[1] Prensky, M., (2001), "Digital Natives, Digital Immigrants, Part I," On the Horizon,vol. 9, no. 5, p. 1; available from http://www.marcprensky.com/writing/

[2] IDC Press Release, "Tablet Shipments Forecast to Top Total PC Shipments in the Fourth Quarter of 2013 and Annually by 2015, According to IDC", Retrieved from http://www.idc.com/getdoc.jsp?containerId=prUS24314413

[3] Handal, B., Ritter, R. & Marcovitz, D., (2014), Implementing Large Scale Mobile Learning School Programs: To BYOD or not to BYOD. In *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2014* (pp. 796-801). Chesapeake, VA: AACE.

[4] Evans, R., & Matthew, A. F., (2013), A new era: personal technology challenges educational technology. In Proceedings of the 30th Ascilite Conference. Sydney, Australia: ASCILITE.

[5] Stead, G., Sharpe, B., Anderson, P., Cych, L., & Philpott, M., (2006), Emerging technologies for learning, Coventry, UK: Becta

[6] Cochrane T. and Bateman R., (2009), "Smartphones give you wings: Pedagogical affordances of mobile Web 2.0, Australian Journal of Educational Technology, 2010; 26(1), 1-14

[7] Astin, A., (1984), Student involvement: a developmental theory for higher education.Journal of College Student Personnel, 25(4), 297–308

[8] Kuh, G. D. (2009). What student affairs professionals need to know about student engagement.Journal of College Student Development, 50(6), 683–706

[9] Pascarella, E. T., & Terenzini, P. T., (2005). How college affects students: A third decade of research. San Francisco, CA: Jossey-Bass

[10] Bandura, A., (1977), Social learning theory

[11] Vygotsky, L. S., (1978), Mind and society: The development of higher mental processes, Harvard University Press

[12] Lave, J. and Wenger, E., (1991), Situated learning: legitimate peripheral participation. Cambridge : Cambridge University Press

[13] Oblinger, D., (2003), "Boomers, Gen-Xers, and Millennials: Understanding the 'New Students,'" EDUCAUSE Review,vol. 38, no. 4, pp. 37–47, Retrieved from: http://www.educause.edu/apps/er/erm03/erm034.asp

[14] Cotner, S., Fall, B., Wick, S., Walker, J., & Baeplar, P., (2008), Instant feedback assessment methods: can we improve engagement, enjoyment, and preparation for exams in large-enrolment biology courses? Journal of Science Education and Technology, 17, 437-443

[15] Draper, S. W. & Brown, M. I., (2004), Increasing interactivity in lectures using an electronic voting system, Journal of Computer Assisted Learning, 20, 81-94

[16] Denso Wave, (1994), QR Code and QR Code features, online document. Retrieved Sep. 2014 from http://www.qrcode.com/en/history/
[17] Ramsden, A., (2008), *The use of QR codes in Education: A getting started guide for academics.* Working Paper. University of Bath
[18] Susono, H, & Shimomura. T., (2006), "Using mobile phones and QR codes for formative class assessment.", *Current developments in technology-assisted education* 2, 1006-1010
[19] Shin, D. H., Jung, J., & Chang, B. H., (2012), The psychology behind QR codes: User experience perspective. *Computers in Human Behavior*, *28*(4), 1417-1426.
[20] Canadi, M., Hopken, W., & Fuchs, M.,(2010), Application of QR Codes in online travel distribution. Information and Communication Technologies in Tourism. In Proceedings of the international conference in Lugano, Switzerland. February 10–12, 2010. Springer Vienna 2010. p. 137–148
[21] Roschelle, J., (2003), Keynote paper: Unlocking the learning value of wireless mobile devices. Journal of Computer Assisted Learning, 19: 260–272. doi: 10.1046/j.0266-4909.2003.00028.x
[22] Sharples, M, Taylor J, and Vavoula, G., (2010), "A theory of learning for the mobile age." *Medienbildung in neuen Kulturräumen*. VS Verlag für Sozialwissenschaften, 87-99.
[23] Cochrane, T. Antonczak, L; Guinibert, M; & Mulrennan, D., (2014), "Developing a mobile social media framework for creative pedagogies", Proceedings of the 10th International Conference on Mobile Learning, pp. 207-214
[24] Yu, F. (2012). Mobile/Smart Phone Use in Higher Education. In M. Rao (Ed.), Southwest Decision Science Institute Conference (pp. 831–839). Houston, Texas, USA: Decision Sciences Institute, Retrieved from http://www.swdsi.org/swdsi2012/proceedings_2012/papers/Papers/PA144.pdf
[25] Law, C.-Y., & So, S. (2010), QR Codes in education. Journal of Educational Technology Development and Exchange, 3(1), 85-100
[26] UCAS Media, (2014), *Eight out of ten freshers have smartphones.* Retrieved from: http://www.ucasmedia.com/2014/eight-out-ten-freshers-have-smartphones. Last accessed 15th September 2014.
[27] Homme, J., Asay, G. & Morgenstern, B., (2004), Utilisation of an audience response system, Medical Education, 38(5), 575
[28] Clerk, R. E., (1983), reconsidering research on learning from media, Review of Educational Research, 53(4), 445-459
[29] Bruff, D., (2009), Teaching with classroom systems: Creating active learning environments. San Francisco, CA: Jossey-Bass
[30] Stes. A., Min-Leliveld. M., Gijbels. D., & Van Petegem. P., (2010), The impact of instructional development in higher education: the state-of-the-art of the research, Educational research review, 5(1), 25-49
[31] Weimer. M. & Lenze. L. F., (1991), Instructional interventions: a review of the literature and interventions. In J. C. Smart (Ed). Higher education: Handbook of theory and research, Vol VII (pp. 294-333), New York, NY: Agathon Press
[32] James. M. C., (2006), The effect of grading incentive on student discourse in peer instruction, American Journal of Physics, 74(8), 689-691
[33] James. M.C., Barbieri. F. & Garcia. P., (2008), What are they talking about? Lessons learned from a study of peer instruction, Astronomy Education review, 7(1), 37-43
[34] Fies. C. & Marshall. J (2006), Classroom response systems: a review of the literature, Journal of Science Education and technology, 15(1), 101-109
[35] Kaleta, R., & Joosten, T., (2007), Student response systems: A University of Wisconsin system study of clickers. *Educause Center for Applied Research Research Bulletin*, *10*(1), 12
[36] Black, P. and Wiliam, D. (1998), Assessment and Classroom Learning', *Assessment in Education: Principles, Policy & Practice,* 5(1), 7-74. Clarke 2005
[37] Keeley, P. (2008), *Science Formative Assessment - 75 practical strategies for linking assessment, Instruction and learning. ,* California: NSTA press & Corwin Press
[38] Knight. P. & Yorke. M., (2003), Assessment learning and employability, Maidenhead, UK: McGraw-Hill Education
[39] Murphy, R and Sharma, N., (2010), "What Don't we know about interactive lectures?", Seminar. net–International journal of media, technology and lifelong learning, pp. 111
[40] Law, R, (2012), Using Quick Response Codes for Student Interaction During Lectures, ITiCSE, ACM 978-1-4503-1246
[41] Angelo, T A., & K. Patricia Cross. (1993), "Classroom assessment techniques.", Retrieved from http://ww2.harford.edu/LAC/pdf%20files/classroom_assessment_techniques%20Angelo%20Cross.pdf

[42] Perez, S. (2014). *Mobile App Usage Increases In 2014, As Mobile Web Surfing Declines.* Available: http://techcrunch.com/2014/04/01/mobile-app-usage-increases-in-2014-as-mobile-web-surfing-declines/. Last accessed 25th September 2014.
[43] Denny, P., Hamer, J., Luxton-Reilly, A., & Purchase, H., (2008). PeerWise: students sharing their multiple choice questions. In *Proceedings of the fourth international workshop on computing education research* (pp. 51-58). ACM.